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Qureshi et al.

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(54) **WALL-MOUNTED SMART SWITCHES AND OUTLETS FOR USE IN BUILDING WIRING FOR LOAD CONTROL, HOME AUTOMATION, AND/OR SECURITY PURPOSES**

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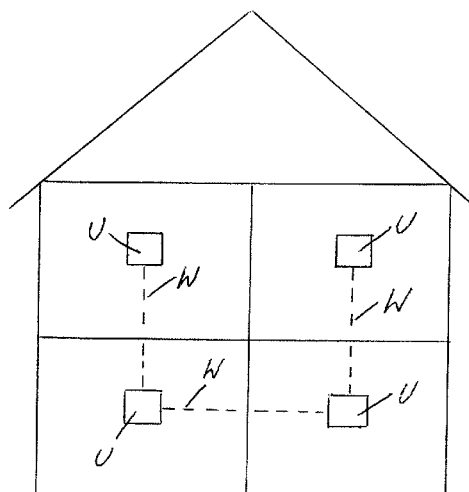
(57) **ABSTRACT**

Electrical switch devices are installed at in-wall electrical boxes of a building. Each device features a switch module with multiple electrically controlled switches for respective connection of multiple load circuits. A control panel with a user interface is mountable over the electrical box and is connected or connectable to the switch module. A communications transceiver of each device is operable to transmit and receive communications to and from each of the other devices. The control panel has a touch-screen display, and is configured to display virtual on-screen switches, including at least one virtual switch whose output is assigned to a respective one of the electrically controlled switches of the other devices. The at least one virtual switch at one device is thereby operable to control at least one load at another of said devices. User selected names are assignable to the switches, and used to label the virtual switches.

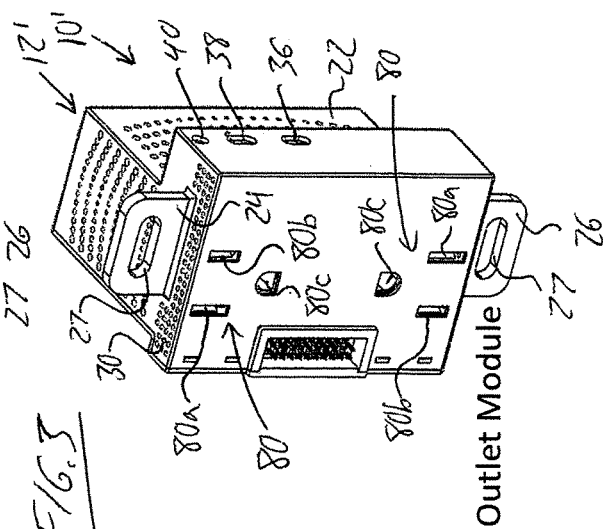
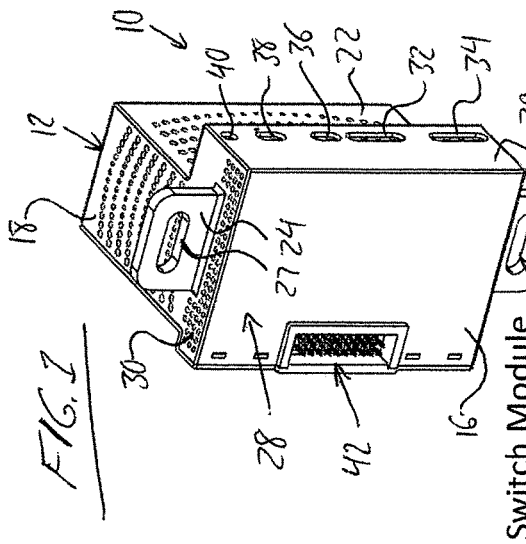
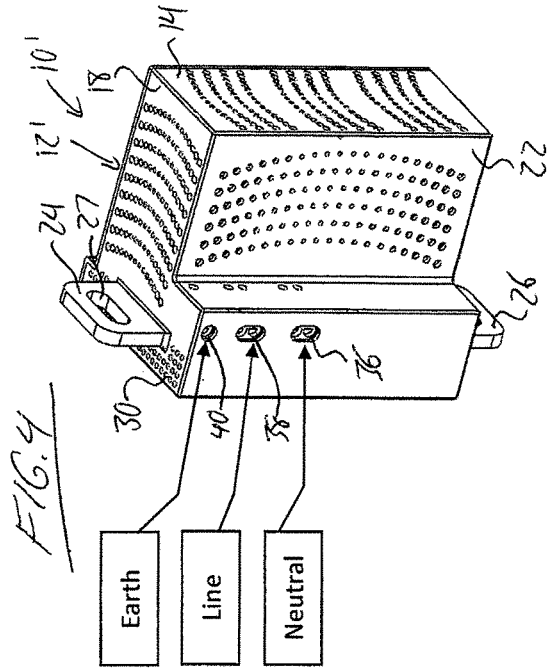
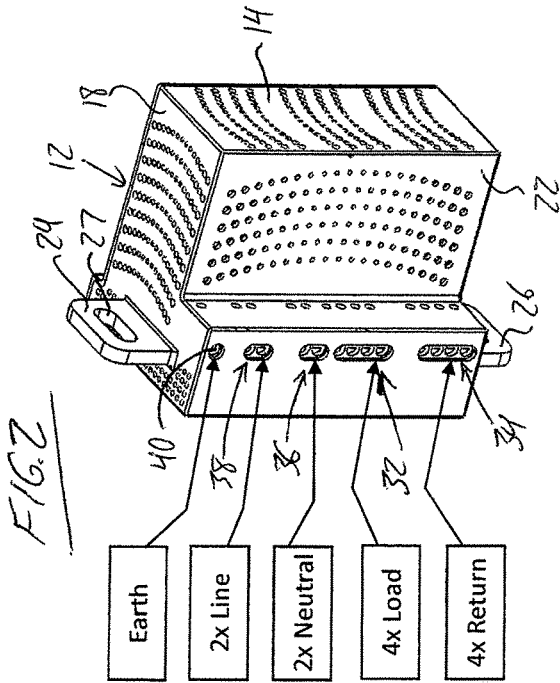
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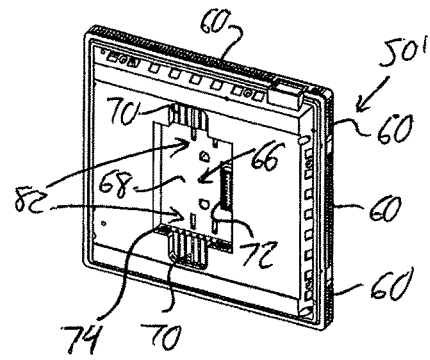
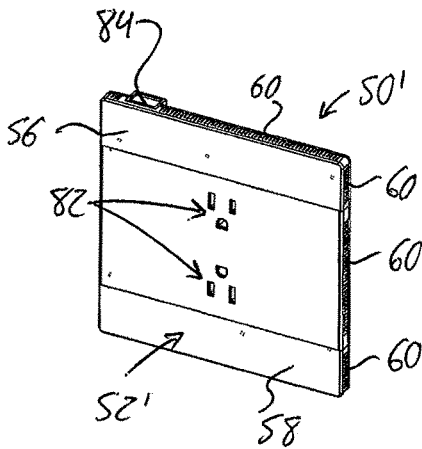
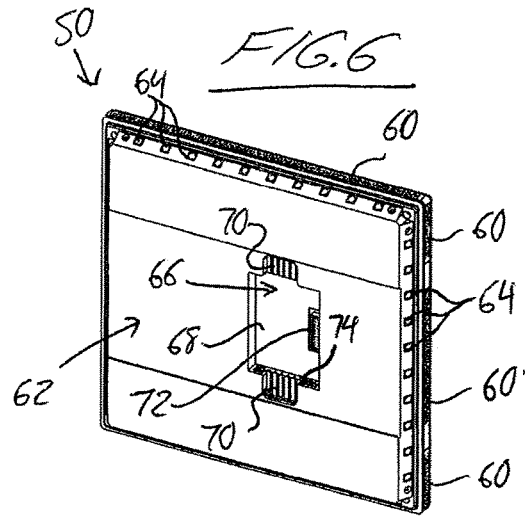
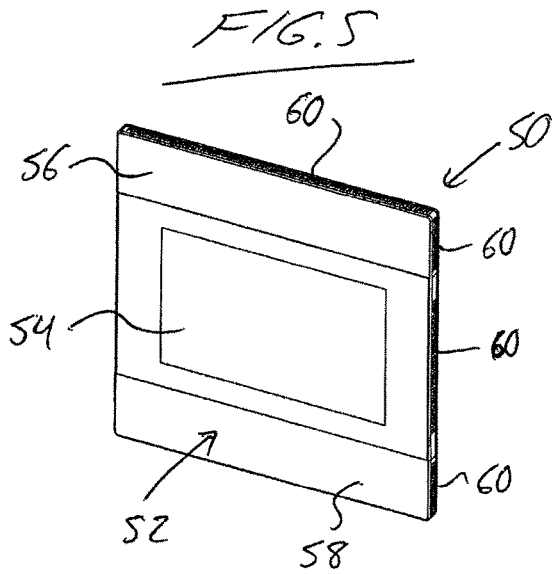
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3 Claims, 4 Drawing Sheets



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See application file for complete search history.





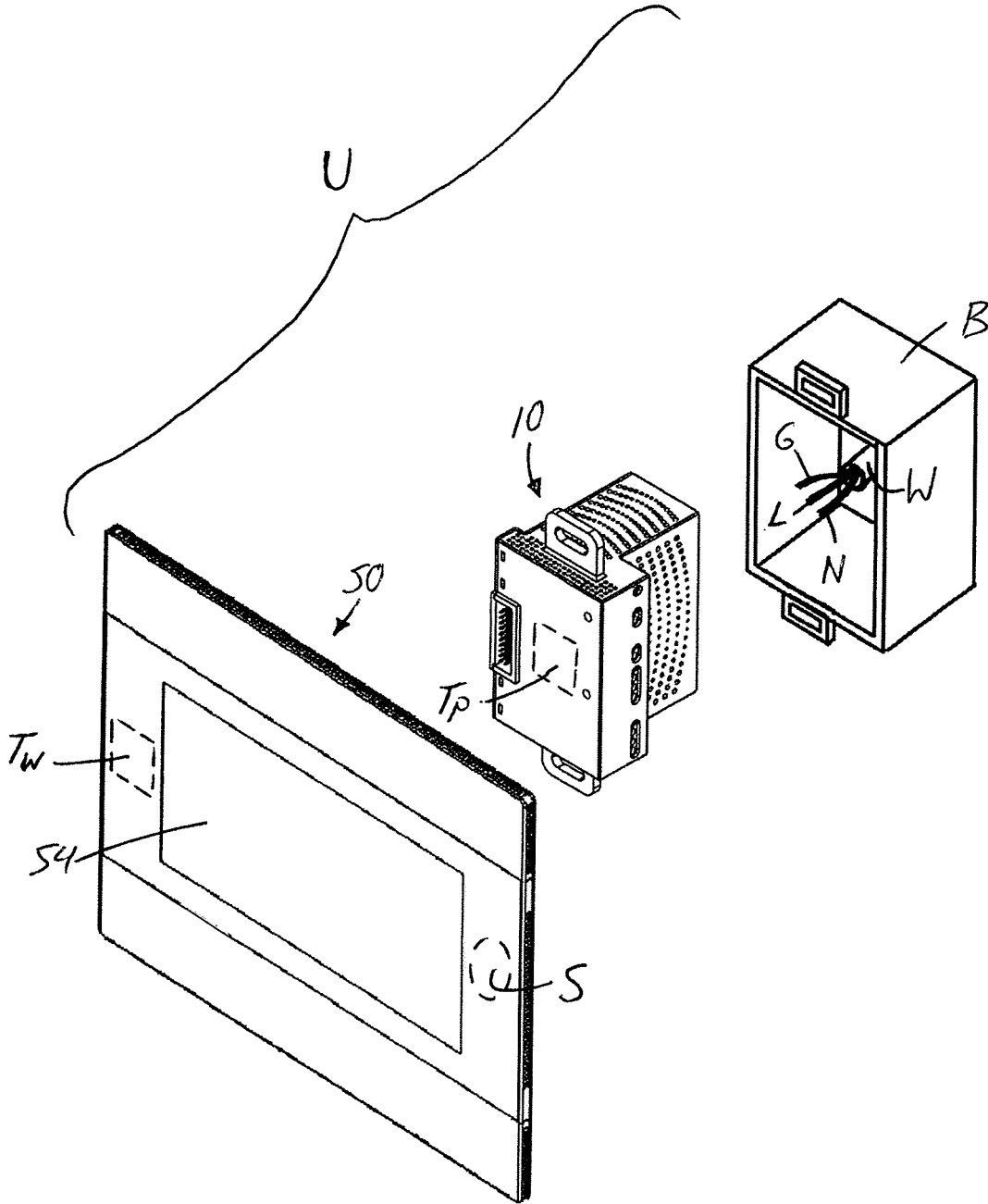


FIG. 9

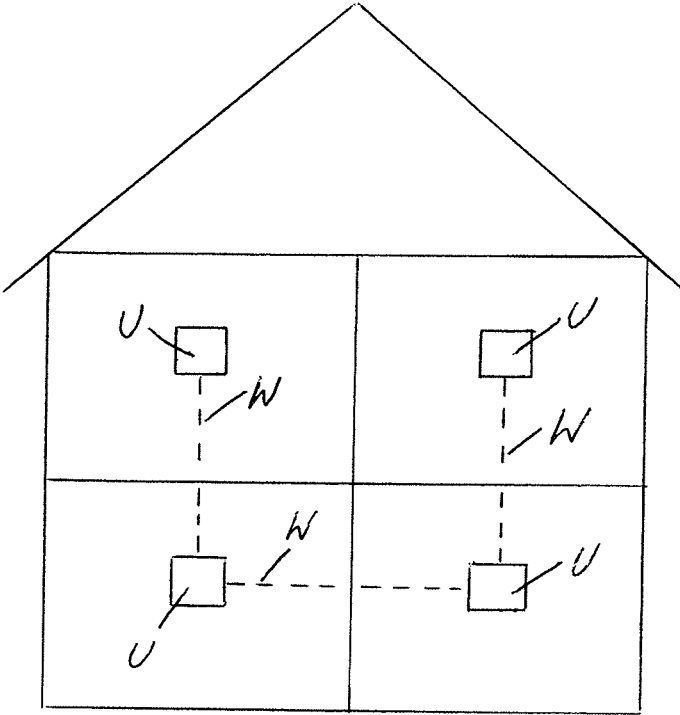


FIG. 10

**WALL-MOUNTED SMART SWITCHES AND
OUTLETS FOR USE IN BUILDING WIRING
FOR LOAD CONTROL, HOME
AUTOMATION, AND/OR SECURITY
PURPOSES**

CROSS REFERENCE TO RELATED
APPLICATIONS

This application is a continuation of U.S. Non-provisional application Ser. No. 14/884,227, filed Oct. 15, 2015, which claimed benefit under 35 U.S.C. 119(e) of U.S. Provisional Application No. 62/064,168, filed Oct. 15, 2014, both of which are incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

The present invention relates generally to wall mounted switches and outlets for controlling electrical loads that rely on mains power distributed thereto through concealed electrical wiring in the walls of a building, and more particularly to smart switches and outlets that are substitutable for conventional mechanical switches and unswitched sockets in retrofit applications to add extra features and functionality, and can also be easily installed using conventional electrical boxes for new installation applications.

BACKGROUND OF THE INVENTION

It is known in the prior art to replace conventional mechanical light switches, e.g. toggle switches, with electronic alternatives in order to provide additional functionality over the control of the light(s) or other load device(s) in the circuit wired to that switch. Examples of such added functionality that can be incorporated with a retrofit electronic switching device include touch-based or proximity-based control over the load circuit, remote control of the load circuit from elsewhere in the same building, and incorporation of the switch devices into home-automation systems with various light settings that can be user-activated or cycled on a programmed scheduled.

Such Home automation systems typically also provide climate control by automatically controlling connected HVAC equipment, and have also been known to incorporate or cooperate with home security systems to provide intrusion detection and alarm activation. Known alarm systems also incorporate video capture functionality in order to record such an intrusion, for example to aid in criminal investigation of the event, and provide remote real-time notification to homeowners of such an event via mobile devices such as mobile phones and computer tablets.

Applicant has developed a unique system that, in one embodiment, incorporates all these functions, and more, and can be easily retrofitted into an existing home to provide wall-mounted controls conveniently located through the premises in a manner avoiding the need for running new wiring and making use of existing electrical boxes to support the wall mounted controls without need for any drywall repair or other customization of the wall space.

Numerous other advantages and unique aspects of the invention will be readily appreciable from the further description and illustration of the invention set out herein.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided a system comprising a plurality of electrical switch

devices for installation at respective in-wall electrical boxes for control over electrical loads of a building, each electrical switch device comprising:

5 a switch module comprising a plurality of electrically controlled switches, and a respective set of line and neutral contacts for each of said plurality of electrically controlled switches to enable connection of a different respective load circuit across each of said plurality of electrically controlled switches;

10 a control panel mountable over an open front of the in-wall electrical box and having a user-interface to enable operation of said control panel by a user;

15 a connection connected or connectable between the control panel and the switch module to enable transmission of signals from the control panel to the switch module, including control signals operable to control the plurality of electrically controlled switches of the switch module; and

20 a communications transceiver operable to transmit and receive communications to and from each of the other electrical switch devices;

wherein the control panel of each electrical switch device comprises a touch-screen display, and is configured to display virtual on-screen switches on said touch-screen display, including at least one virtual switch whose output is assigned to a respective one of the electrically controlled switches of the other electrical switch devices, whereby the at least one virtual switch at one of said electrical switch devices is operable to control at least one load at another of said electrical switch devices.

30 In one embodiment, the control panel of each electrical switch device is configured to enable user-selected naming of the electrically controlled switches of the switch module of that electrical switch device, and the control panel of each electrical switch device is configured to automatically label the at least one virtual switch on the touch-screen display with a user-selected name of the respective one of the electrically controlled switches to which the output of the virtual switch is assigned.

40 In one embodiment, the control panel of each electrical switch device is configured to enable change of the touch screen display between a switching mode showing the virtual on-screen switches, and one or more pre-set modes with selectable pre-sets for the load circuits of one or more of the electrical switch devices.

45 In one embodiment, the control panel of each electrical switch device is configured to enable change of the touch screen display between a local pre-set mode with selectable pre-sets for one or more loads connected to a singular one of the electrical switching devices, and one or more wide pre-set modes with selectable pre-sets for a plurality of loads connected to a group of the electrical switching devices.

BRIEF DESCRIPTION OF THE DRAWINGS

55 One embodiment of the invention will now be described in conjunction with the accompanying drawings in which:

FIG. 1 is a front perspective view of a switch module of the present invention, whose housing is small enough for mounting in a single-gang in-wall electrical box while containing four electronically controlled switches that can replace up to four conventional mechanical switches.

60 FIG. 2 is a rear/side perspective view of the switch module of FIG. 1, which includes wire connection terminals through which up to four load circuits can be connected, and by which the module is connectable within a power line communications network featuring additional switch modules.

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FIG. 3 is a front perspective view of a switchable socket module of the present invention, which features two sockets by which the plugs of two conventional power cords can be connected to two electronically controlled switches inside the module.

FIG. 4 is a rear/side perspective view of the socket module of FIG. 2, which features the same power line communication terminals as the switch module of FIGS. 1 and 2.

FIG. 5 is a front perspective view of a touch screen control panel that is mateable with the switch module of FIG. 1 to support the control panel thereon in a wall-mounted that conceals the drywall opening in which the electrical box is mounted.

FIG. 6 is perspective view of a rear face of the touch screen control panel of FIG. 5, which features a rectangular recess for matingly fitting over a front end of the switch module that juts out from the electrical box in order to carry the control panel in the wall mounted position and establish a communication and power connection between the switch module and control panel via mating connectors thereon.

FIG. 7 is a front perspective view of a socket control panel that is mateable with the switchable socket module of FIG. 3 to support the control panel in a wall-mounted position concealing the drywall opening in which the electrical box is mounted.

FIG. 8 is a rear perspective view of the socket control panel of FIG. 7, which features the same recess and connector as the touch screen control panel of FIG. 6 for similar mounting of the socket control panel on the socket module of FIG. 3.

FIG. 9 illustrates assembly of the switch module of FIG. 1 and touch screen control panel of FIG. 5 with an electrical box to form a wall mounted unit.

FIG. 10 illustrates installation of multiple in-wall units throughout a building to enable multi-room music playback through the power line communications network.

DETAILED DESCRIPTION

FIG. 1 shows an electronic switch module 10 of the present invention that mounts in a conventional in-wall electrical box, for example in place of a conventional mechanical switch previously mounted therein. A control panel, such as that shown in FIGS. 5 and 6 mates with the electronic switch module in manner both mechanically supporting the control panel thereon and establishing a power and communication link between the panel and the switch module, whereby the control panel enables user control over one or more electrical loads (e.g. lighting fixtures, exhaust fans, or other permanently-wired household fixtures) that are wired to the switch module 10 during installation of the module.

The switch module 10 features an outer housing 12, inside of which there are contained four electronically controlled switches, a power supply for converting AC mains power to DC power for operating the switch module components, a power line communications transceiver, power metering components, a first processor operatively connected to the power line communications transceiver to process incoming signals received at the transceiver and transmit outgoing signals from the transceiver, and a second processor operatively connected to the power metering components to monitor power consumption by any load circuit that is connected to the four electronically control switches.

The illustrated housing features a planar vertical rear panel 14, a wider planar vertical front panel 16 of equal

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height lying parallel and opposite thereto, and planar horizontal top and bottom panels of equal size and shape interconnecting the front rear housing panels 14, 16. The top and bottom housing panels, of which only the top panel 18 is visible in the drawings, are generally T-shaped due to the wider configuration of the housing 12 at its front end than its opposing rear end, which therefore also gives the overall housing a generally T-shaped structure in plan view. As a result, each side of the housing 12 is divided into two planar vertical side panels, specifically a front side panel 20 connected perpendicularly to the front panel 16 and a rear side panel 22 connected perpendicularly to the rear panel 14. As shown, the top and bottom housing panels are perforated with arrays of holes covering a substantial area of each, as are the rear side panels and the rear panel, in order to form airflow openings by which air can flow through the housing in different directions to cool the electronic components contained therein.

An upper mounting bracket 24 stands perpendicularly upright from the top housing panel 18 at the crossing portion of its T-shape in a vertical plane parallel to that of the front housing panel 16 at a distance set a short distance back therefrom. A matching lower mounting bracket 26 reaches perpendicularly downward from the bottom housing panel at a position matching that of the upper bracket 24. Each bracket 24, 26 has a slot-shaped through-hole 27 of horizontally elongated shape, through which the brackets 24, 26 can be screwed to the pair of upper and lower screw holes situated above and below a mounting space of a conventional electrical box at the open front thereof.

The distance from the plane of the mounting brackets 24, 26 to that of the rear panel 14 is less than the depth of a standard sized single-gang electrical box, and the distance between the two front side panels is likewise less than the width of a standard sized single-gang electrical box. Accordingly, when the brackets 24, 26 are fastened to the screws holes of the electrical box, the substantially majority of the housing 12 spanning rearwardly from the mounting tabs 24, 26 will reside within the interior space of the electrical box. In this mounted position of the switch module 10, a front portion 28 of the housing 12 spanning forwardly from the plane of the mounting tabs 24, 26 juts a short distance out of the electrical box through the open front thereof. The airflow openings in the top and bottom housing panels include an array of airflow openings 30 situated in front of the mounting tabs 24, 26 at this front portion 28 of the housing 12.

The switch module 20 is thus mountable in a single-gang electrical box, but can likewise be mounted at a single gang site of a multi-gang electrical box. As the switch module 20 contains four electronic switches, a single switch module 20 can be mounted in a one-gang, two-gang, three-gang or four-gang in order to take the place of one, two, three or four conventional mechanical switches without any loss of load handling capability or switching functionality. That is, in the event that an existing four-gang box contained four mechanical switches, each controlling a respective load circuit wired to that particular switch, mounting of a single switch module 10 of the present invention at one of the four available gang spaces in the four-gang electrical box allows those same four load circuits to be connected to the switch module for control of these circuits via the four electronic switches inside the module 20. In preferred embodiment, each electronic switch preferably includes a dimming function, whereby dimming functionality of a light fixture is maintained if it was previously wired to a conventional dimming switch. In addition, the installation of the module

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adds the dimming functionality to a light that was previously wired only to a basic on-off toggle switch. Known dimmable electronic switch circuits using gate-controlled TRIACs or MOSFETS can be employed for the electronic switches of the present invention, which are therefore not detailed further herein.

To enable connection of the load circuits, the front side panel **20** on one side of the housing **12** features a series of exposed connection terminals arranged vertically therealong near the rear edge thereof so as to reside behind the mounting straps **24**, **26**. This way, the connection terminals and any wires connected thereto remain safely inside the interior space of the electrical box when the switch module is mounted thereto. The connection terminals are grouped into visually distinct clusters or groups, for example each defined by a respective terminal block. One terminal block **32** features four 'load' terminals for connecting a wire from each electronic switch out to a respective load circuit, and another four-terminal block **34** likewise provide four 'return' terminals for connecting the return wire from each load circuit to the respective electronic switch inside the housing. Another terminal block **36** features two terminals for connection of one or two 'neutral' wires, and a second two-terminal block **38** features two terminals for connection of one or two 'line' or 'hot' wires. If the switch module is the only module on a branch circuit of a circuit breaker panel, then only one 'neutral' wire and one 'line' wire are connected. To install another switch module on the same circuit, then the second pair of 'neutral' and 'line' terminals are employed to connect the second module to the circuit breaker panel in parallel with the first switch module. The line and neutral connections provide the input to the switch module's DC power supply that powers the switch module's internal components, and connect across the four parallel electronic switches in order to provide AC power to any load circuit connected to the module. The line and neutral connections also enable transmission and receipt of power line communication signals by the switch module **10**. A final single terminal block **40** defines a ground or earth terminal of the switch module.

A female connection port **42** is left open at the otherwise rectangular front panel **16** of the switch module housing **12** so that an array of contact pins in the female connection port can be engaged with the contacts of a mating male connector on the control panel in order to establish a power and communication connection between the switch module and the control panel via mating of these connectors. The electronic components of the control panel are powered from the DC power supply of the switch module through this connection, which also enables signals from the control panel to control the four electronic switches of the switch module **10** through this connection.

FIGS. **5** and **6** show a touch screen control panel **50** for use with the switch module **10** of FIGS. **1** and **2**. With particular reference to FIG. **5**, a generally rectangular planar front face **52** of the control panel faces away from the switch module and the electrical box in which the switch module is mounted when the control panel **50** is installed. The front face features a centrally positioned touch-screen display **54**, an upper touch-pad **56** residing above the touch-screen **54** and spanning the width of the front face **52** along the upper edge thereof, and a matching lower touch-pad **58** residing below the touch-screen **54** and spanning the width of the front face **52** along the upper edge thereof.

Turning to FIG. **6**, a generally rectangular planar rear face **62** of the control panel **50** lies parallel to the front face. As shown, the rear face **62** may be slightly smaller in width and

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height than the front face, with the enclosure or casing of the thickness of the control panel thus being divided into a front portion of slightly greater circumferential or peripheral size than the rear portion. The four perimeter edges of the control panel's front portion feature slot-shaped airflow openings **60** extending therealong. The four perimeter edges of the control panel's rear portion, which are set back slightly inward from the perimeter edges of the larger front portion, each feature a series of multi-colour LED units **64** set therein at equally spaced intervals around the periphery of the rear portion of the control panel to provide outwardly radiating light from the rear portion of the control panel enclosure. When the control panel is installed, these LED units **64** provide ambient lighting effects on the wall surface over which the control panel is mounted.

The processor of the control panel may execute pre-programmed, user-programmed or user-customizable wall lighting routines in which the different LED units are activated and deactivated, and/or varied in output lighting colour and/or output light intensity (or brightness) in sequential, random or other patterns to create a dynamic lighting effect, as an alternative to static ambient lighting. One example includes a 'sunrise' lighting effect, in which all LED units are activated in a same colour, and gradually increase in output intensity so that the annular casting of light on the wall around the control panel gradually increases in diameter. This may include variation of the colour (e.g. temperature) as the intensity or brightness is increased. The sunrise lighting effect may be incorporated into a wake-up alarm routine, accompanied by playback of audio signals (e.g. music) through the local speakers of the control panel (as discussed in more detail below) in a manner gradually increasing the volume of the audio as the light intensity is likewise increased over time. Another lighting effect is a 'northern lights' effect with a colour variation display in which in which all the LEDs are illuminated in an initial first colour, and then moving sequentially around the control panel in one or both directions, are changed to another output colour, whereby a ring of colour lighting washed onto the wall around the control panel gradually changes from one colour to another as an arc of one colour gradually grows in circumferential span around the control panel, while the arc of the previous colour gradually reduces in circumferential span around the control panel.

A recessed area **66** in the otherwise planar rear face **62** of the control panel **50** features a main rectangular area **68** whose dimensions are generally equal or slightly greater than the rectangular dimensions of the front panel **16** of the switch module. As a result, the recessed area **66** of the control panel's rear face **62** can be matingly fitted over the front portion **28** of the switch module **10** that juts forwardly out of the open front of the electrical box at the finished interior surface of the drywall or other finishing material of the wall in which the electrical box resides.

The front portion of the switch module **10** thus reaches into the room from the drywall in order to form a mounting feature on which the control panel can be hung. Suitable mechanical interlock means are preferably defined between the recess of the control panel and mating front portion of the switch to provide secure, confident retention of the control panel on the switch module when the male front end of the switch module is fitted into the female recess at the rear of the control panel. Smaller recesses **70** of lesser width and depth than the main rectangular area **68** of the recess extend upward and downward therefrom, and are sized to fit over the mounting tabs **24**, **26** of the switch module **10** when

the control panel **50** is mounted thereon. As a result, the rear face **62** of the control panel **50** fits flush against the drywall or other finished surface of the wall around the electrical box in order to fully conceal the electrical box and the switch module behind the control panel.

A male connector **72** is situated in the main rectangular recess **68** at a position therein that self-aligns and mates with the female port **42** at the front panel **16** of the switch module **10** when the recess **66** is fitted over the protruding front portion **28** of the switch module **10**. This way, the power and communication connection between the switch module and the control panel is automatically established by placement of the control panel onto the switch module without need for separate connection of a cable during the installation process. Although described as being generally T-shaped due to its wider front end than rear end, the front panel **16** of the switch module **10** is not symmetrical in terms of its lateral reach, instead jutting further to one side of the housing than the other. In the instance of the illustrated embodiment, the front portion of the housing reaches further outward at the terminal-equipped side of the housing **12**. The mounting brackets **24**, **26** are not centered across the width of the front panel **16** of the switch module housing, and the mounting bracket recesses **70** of the control panel are likewise offset from the center of the main rectangular recess **68**. This way, the control panel can only fit onto the switch module **10** in a proper right-side-up orientation, thereby ensuring the alignment and connection between the communication and power connection features **42**, **72** by preventing sliding of the touchscreen onto the switch module in the improper orientation.

The peripheral size of the control panel **50**, even at the smaller rear half thereof, exceeds that of a standard four-gang electrical box, whereby the surface area of the control panel **50** will completely cover the open front of any conventional one-gang, two-gang, three-gang or four-gang electrical box. To such end, the control preferably measures a minimum of 8-centimeters high by 19-centimeters wide. Accordingly, with the switch module **10** mounted in any existing electrical box, no separate cover-panel or finishing-panel is required to provide a clean, finished appearance, as the opening in the drywall around the existing electrical box is fully concealed behind the control panel **50**. Due to the overhanging position of the switch module, in which its front portion juts out past the drywall or other finished surface of the wall, the control panel is flush mounted against the wall without requiring any intermediate bracket or support between the box-mounted switch module **10** and the control panel **50**. Also, no enlargement of the existing drywall opening is required to accommodate this flush-mount condition of the control panel. Retrofit installation at an existing switch site is thus greatly simplified, requiring only deactivation of the respective circuit breaker at the panel, removal of the existing switch's cover plate, removal of the existing switch and disconnection thereof from the existing building wiring, connection of the building wiring to the switch module **10**, fastening of the switch module to the electrical box, and simple male/female mating of the control panel to the switch module. The process is the same, regardless of the number of switches being replaced in the electrical box, as only one switch module unit needs to be installed, even if two, three or four mechanical switches are being replaced in the same gang box.

FIG. 9 illustrates the above described assembly of the switch module **10** and control panel **50** on an electrical box **B** to form a finished wall-mounted unit **U**. As described above, the switch module **10** is fastened through its mount-

ing brackets **24**, **26** to the electrical box **B** and the line, neutral and ground wires **L**, **N**, **G** of the building wiring **W** are connected to the appropriate terminals of the switch module **10** inside the box **B**, thereby mounting the switch module **10** to the wall and establishing connection between the building wiring **W** and the power line communications transceiver T_P inside the switch module **10**. The control panel **50** is then fitted over the front portion of the switch module **10**, thus supporting its various components, including its schematically illustrated wireless transceiver T_W and speaker **S**, on the wall.

The airflow slots **60** in the perimeter edges of the control panel **50** are in fluid communication with one another through the interior space of the control panel's enclosure to enable airflow therethrough. Likewise, the array of airflow holes **30** in the top panel **18** of the switch module housing **12** are in fluid communication with those of the opposing bottom panel of the switch module housing **12**. In addition, an array of airflow holes **74** is provided in each of the top wall and bottom wall **68a** of the main rectangular recess **68** at the rear of the control panel **50**. The airflow holes **74** in the bottom wall of the recess **68** are in fluid communication with at least the airflow slots of the bottom perimeter edge of the control panel enclosure, and the airflow holes (not shown) in the top wall of the recess **68** are in fluid communication with at least the airflow slots of the top perimeter edge of the control panel enclosure **50**. As a result, the airflow openings in the control panel and the switch module provide a through-flow air passage passing fully through both the control panel and the switch module when assembled. This helps cool the electronic components of the switch module that is otherwise substantially enclosed by the electrical box and overlying control panel. A fan may be incorporated into one or both components as a forced air cooling means to encourage airflow through the assembled units via this flow-through air passage.

FIGS. 3 and 4 show a switchable outlet or socket module **10'** of same size and shape as the switch module **10** of FIGS. 1 and 2 for mounting to a single-gang electrical box in the same manner as the switch module, but as a replacement for a conventional electrical outlet instead of as a replacement for a conventional mechanical switch. The housing **12'** of the outlet or socket module **10'** is of the substantially the same configuration, except that a reduced number of connection terminals are included, and the front panel **16** of the housing features two sets of socket openings **80** therein.

Inside the housing, the outlet or socket module **10'** differs from the switch module **10** in that it features only two electrically controlled switches (e.g. gate-controlled TRI-ACs) and associated power metering components. Instead of having load and return terminal blocks **32**, **34** for use in connecting permanently wired fixtures to the electronic switches, each electronic switch instead has a respective pair of neutral and hot contacts respectively disposed behind the two blade-shaped openings **80a**, **80b** of one of the two sets of socket openings **80**. This way, plugging the two blades of a conventional electrical plug into the blade shaped openings **80a**, **80b** of the socket module **50'** will electrically connect the plug-equipped device or appliance to the respective electronic switch of the socket module. Each set of socket openings **80** is completed by a ground pin opening **80c** for receiving the ground pin of a conventional three-pin grounded plug. Although the illustrated embodiment features blade shaped socket openings for the flat, blade-like shape of standard North American 120V plugs, it will be appreciated that other standard plug/socket layouts and

shapes may be employed, for example according to national or regional standards used in other jurisdictions.

FIGS. 6 and 7 show a socket control panel 50' sharing many features of the touch screen control panel 50 of FIGS. 5 and 6. Unlike the user interface of the touch-screen panel 50, which features both a touch-screen and two touch pads, the user interface of the socket control panel 50' has only the two touch pads 56, 58 and no touch screen. The central area of the front face 52' of the socket control panel 50' instead features two sets of socket openings 82 therein, which pass through into the main rectangular recess 68 in the rear face 62 of the socket control panel 50'. The socket control panel 50' and the socket module 10' fit together in the same manner as the touch-screen control panel 50 and switch module 10, and cooperate in a similar manner to provide control over the switchable on/off state of the electronic switches inside the module housing 12'. The socket openings 82 in the socket control panel align with the socket openings 80 in the socket module to allow the blades or pins of an electrical plug to reach through the aligned openings into engagement with the contacts in the socket module.

As the socket module 10' is intended only as a replacement for a conventional electrical outlet mounted in a single-gang electrical box, the socket control panel 50' may be of a smaller footprint than the touch-screen control panel 50 that is compatible with multi-gang electrical boxes. Accordingly, the size of the socket control panel may be smaller, so long as it is sufficient to fully and confidently conceal a single-gang electrical box, the drywall opening cut therearound, and the socket module 10' mounted to the electrical box.

In addition to the electronic switches, touch panels, touch screen and wall effect surround LEDs, additional built in components of the touch screen control panel 50 of the preferred embodiment also include a camera that faces outward from the panel to capture video and/or still images of the environment in which the panel is installed, a microphone for detecting and recording audible events, at least one speaker (and preferably a pair of stereo speakers) for outputting audio, a wireless transceiver (e.g. WiFi or Bluetooth), and sensors for detecting environmental conditions such as temperature, humidity, light, movement/proximity, carbon monoxide levels. Aside from its lack of a touch screen, the socket control panel 50' may be comparably equipped to the touch-screen panel. In one embodiment, the socket control panel 50' lacks the camera device and associated video/image capture functionality of the touch screen control panel. The illustrated embodiments of the socket control panel 50' features a charging port 84 in the top peripheral edge of the panel, preferably in the form of a Universal Serial Bus (USB) port in order to define a relatively universal charger than can be used on any of a variety of consumer electronics (e.g. mobile phones, music players, etc.) whose batteries can be charged through the USB port of a desktop or laptop computer. The charging port 84 is powered from the AC/DC power supply in the socket module 10', and provides a continuously available charging source regardless of the particular switched state of the electronically-switched AC sockets 80 of the socket module.

Software of the control panel features statements and instructions stored locally on a local non-transitory computer readable medium within the control panel enclosure for execution by one of the processors of the touch screen panel. The software is operable to present an on-screen touch-operated user interface forming part of a larger overall user interface that includes the upper and lower touch pads

56, 58. The user interface is and is operable to control each electronic switch of the switch module on which the touch-screen is mounted.

The on-screen display may present a visual representation of a mechanical on/off toggle or rocker switch, or sliding or rotary dimming switch, for each and every electronic switch of the switch module. Alternatively, such an on-screen representation may be display only for a select one or more of the electronic switches of the switch module, for example those to which an electrical load has been coupled. In one embodiment, each switch representation or 'virtual switch' may comprise a bound rectangular area in the foreground of the display that is visually distinct from an underlying background colour of the on-screen display. A fill-colour of the rectangular area changes between one colour (e.g. red or orange) that represents an 'on' state of the respective electronic switch, and a different colour (e.g. black or grey) that represents an 'off' state of the respective electronic switch. Touching the respective rectangular area of the screen switches the state of the electronic switch between the 'on' and 'off' state. An on-screen dimmer representation may likewise feature a bound rectangular area, with graduations marked along one or both vertical sides thereof. In such instance, sliding one's fingertip up or down the rectangular area adjusts a dimming level of the electronic switch. The colour, hue or intensity of the bound rectangular area of the dimmer representation may change with the dimming level as the user's operates the touch-based adjustment. The programming mode preferably enables user-specified names to be assigned to each electronic switch, for example according to the particular load(s) connected thereto, e.g. "kitchen light", "bathroom light", etc. On the display screen of the touch-screen control panel, the name of the electronic switch or load can then be displayed at any one or more of the virtual switches assigned to that load.

Each touch pad 56, 58 may be operable to control a respective electronic switch of the switch module, for each with a simple 'single touch' gesture switching between the 'on' and 'off' state, and a sliding or wiping gesture in opposing directions along the length direction of the strip being operable to control to increase and decrease the level of the dimming function. In a user-customization or programming mode, the user-interface may allow the user to specify which one of the electronic switches of the switch module is assigned to each of the two touch pads 56, 58.

With power-line communication available between different switch modules, the user-customization or programming mode of the touch screen interface may allow the user to assign the output of an on-screen virtual switch at the control panel of one switch module, to an electronic switch of one of the other switch modules. Accordingly, addressable electronic switches are used to allow such remote control of one switch module from the control panel of another module. Likewise, the two electronic switches of the socket module 10' may be controlled remotely from the touch-screen module 54. In one embodiment, a system of the present invention may employ only a single touch-screen control panel 50, and instead employ a simplified control panel lacking the touch-screen 54 at each other switch module. This simplified panel may therefore be more comparable in structure and operation to the socket control panel 50', but without the socket openings 82. In other embodiments, more than one touch-screen control panel may be deployed throughout the system.

In embodiments that feature use of the simplified control panel on one or more of the switch modules, the simplified panel may have the a smaller footprint and reduced switch

control capability like those of the socket module, therefore having only two touch pad switches for load control actions. The simplified control panel may be sized so as to fully cover a one-gang or two-gang electrical box, for example having a minimum width of 10 centimeters and minimum height of 8 centimeters, but not large enough to cover three or four gang boxes that can be covered with the larger touchscreen panel. In one embodiment, the simplified switch panel lacks an on-board camera, therefor making it suitable for use in rooms where the owner does not want cameras present for privacy reasons (washrooms, bedrooms, etc.). Many homes tend to use larger three or four gang electrical boxes only in larger open areas where multiple, separately switchable lighting fixtures are present. Single-gang switches are typically used in smaller areas such as bedrooms, where often only a single lighting circuit is employed. Two-gang boxes are commonly employed in bathrooms to allow separate switching of a single lighting circuit and a separate dedicated circuit for a bathroom exhaust fan. The smaller simplified switch panel is therefore suitable for use in such smaller areas of a building, thereby avoiding camera privacy concerns, reducing expense by not including a touch-screen at every single control point or node in the system, and accommodating for situations where there is insufficient wall space to accommodate the larger touchscreen control panel (e.g. at a single or double gang electrical box mounted closely adjacent to wall-mounted doorway casing).

A central control unit (not shown) may be connected to the switch and socket modules of the system, thereby forming a star network in which communications between the switch and socket modules occur via the central control unit. In one embodiment, a security mode of the system can be initiated by a user, during which the microphone and/or proximity/movement sensor of each control panel monitor for signs of a break-in or other security intrusion. Unlike conventional alarm systems in which the sensors are typically stand-alone units with no local signal processing, the local software and processor(s) of the control panel can perform local signal processing to try and rule out false alarms and better distinguish actual alarm-worthy events from among other recorded audio signals.

Upon confirming an intrusion or other alarm-worthy event, the control panel activates its built-in camera and may also begin storing incoming audio signals from the microphone in order to create a visual and audible recording of the alarm-worthy event, for example to aid potential identification of the intruder during in any subsequent investigation by a homeowner, security personnel, or law enforcement agency. The control panel may also activate all of the electronic switches of the connected switch module in order to turn on any and all lights connected thereto, and emit an audible alarm from its speaker(s). The audible alarm may include a siren, and/or other sounds intended to deter would-be burglars or other unauthorized parties from entering the premises, for example playback of a recorded or simulated dog barking audio. Upon local detection of an alarm-worthy event by one control panel, and outgoing alarm confirmation signal is sent from that control panel, via the respective switch module connected thereto, through the power line carrier network in order to activate the lights, alarm and recording functions at all of the other control panels in the network, for example via the central control unit. The central control unit may be connected to a larger network, e.g. the internet, and configured to send an alarm notification alert to a mobile device (e.g. mobile phone, tablet computer, etc.) via SMS message, email, automated phone call, etc.

The system may be used to stream music or other audio to one or more of the control panels for playing through the on-board stereo speakers thereof. Music streaming can be from local or Internet sources. Audio files can be stored on a separate device (e.g. personal audio device, smartphone, external hard drive etc.) which has access to the local system network, for example by way of wireless (e.g. wifi or Bluetooth) communication with one of the control panels, or wired or wireless connection with the central controller. Files are played by streaming these files locally over the power-line Ethernet, or wirelessly (e.g. via Bluetooth or WiFi) to the control panels. Alternatively, music can be streamed over the Internet from a third party service. Music playback can be synchronized across multiple control panels by having a single control panel acts as a central point which distributes and synchronizes playback one, some or all other control panels, thereby enabling simultaneous broadcast of the audio in multiple rooms each having one or more switch or socket modules, and associated control panels, therein. The speakers also enable the system to make audible announcements, for example in response to voice-command requests by a user that are detected by the microphone of a control panel and recognized by voice-recognition software running on the control panel. Such voice-recognition functionality of the control panels also enables voice-control over the electronic switches and other functions of the switch modules.

FIG. 10 schematically illustrates installation of a plurality of wall-mounted units U in different respective rooms of a building, such that the building's wiring W forms a power-line communications network by which the above described streaming of music to multiple rooms can be achieved.

The power line communication between the switch and socket modules of the system not only enables remote-control of an electronic switch from a location other than the particular switch module in which that electronic is found, but also enables room-wide or building-wide pre-sets to be programmed and easily recalled. To elaborate, the system may store one or more 'local pre-sets', i.e. a pre-set that determines the status of one or more loads connected to a single switch or socket module, and 'wide' or 'global' pre-sets, i.e. a pre-set that determines the status of loads connected to a plurality of different switch and/or socket modules at different locations throughout a building. In one embodiment, the touch-screen display of a touch-screen control panel is readily changeable between a 'switching' mode showing a bank of manipulatable virtual switches, a 'local pre-set' mode showing a bank of selectable local pre-sets, and a 'global pre-set mode' showing a bank of selectable global pre-sets. In the embodiment in which the bank of virtual switches are shown as respective elongated rectangular blocks, local pre-sets and global pre-sets may be displayed as bordered areas whose shapes are distinct from one another and from the visual switches, e.g. square areas for local pre-sets and circular areas for global pre-sets. Selecting a pre-set by touch may changes the fill-colour or brightness of the selected pre-set in order to visually confirm the selection, just like the toggling of the virtual switches between 'on' and 'off' states that is confirmed by a visual change in the fill-colour or brightness of the rectangular virtual switch.

Pre-sets may include additional settings beyond mere lighting or load control functions that switch the electronic switches between into predetermined on, off states or dimmed states. For example, a global 'away' pre-set for activation when leaving the premises may activate the alarmed security mode of the system, while also turning off

all the lights, setting a predetermined selection of lights into the 'on' state to simulate the presence of one or more people at the unoccupied building, or executing a sequence of scheduled lighting controls (i.e. periodically switching one or more select lights off, and then switching one or more other lights on) that are intended to more realistically simulate a personal presence in the building rather than merely setting a static continually-on condition of one or more lights. Such a scheduled sequence may be programmed, or 'learned' by the system by monitoring the on and off states among the electronic switches of the system at times outside of the 'away' mode of operation. Pre-sets may also incorporate other functions described herein, for example streaming of music to all or a user-selected subset of the total number of control panels in the overall system, and/or controlling the wall illumination function of one or more control panels. Pre-sets may include 'entertainment' pre-sets incorporating both lighting effects and music playback.

The use of a central control unit also enables connection of additional equipment or auxiliary systems that can then be controlled via the control panels of the present invention without need to provide additional wiring beyond the existing building wiring that is used to connect the switch and socket modules. For example, a furnace, air conditioner, humidifier, dehumidifier, and/or other HVAC or climate control equipment, can be connected to the central module, whereby the temperature sensors at the control panels can be used to implement a programmable thermostat and/or zone-based climate control functionality of the system, with optional humidity control via an included humidity sensor, thereby providing a more complete whole-home automation system.

Other functional aspects that can be incorporated into the system include calendar and event tracking functionality in which events can be entered through the touch-screen user interface and/or voice-recognition functionality, and intercom functionality using the microphones of the control panels (and optionally the cameras thereof if at least one of the control panels being used for an intercom communication has a touch-screen or other visual display).

While the forgoing embodiments incorporate the power line communication transceiver and associated first processor, the power metering components and the associated second processor, and a DC power supply for these processors incorporated within the switch module, these components may alternatively be incorporated into the panel, in which the case the male connector and female port on the panel and switch module for power and data connection therebetween are adapted to provide AC power to the panel.

Since various modifications can be made in my invention as herein above described, and many apparently widely different embodiments of same made within the scope of the claims without departure from such scope, it is intended that all matter contained in the accompanying specification shall be interpreted as illustrative only and not in a limiting sense.

The invention claimed is:

1. A system comprising a plurality of electrical switch devices for installation at respective in-wall electrical boxes for control over electrical loads of a building, each electrical switch device comprising:

- a switch module comprising a plurality of electrically controlled switches, and a respective set of line and neutral contacts for each of said plurality of electrically controlled switches to enable connection of a different respective load circuit across each of said plurality of electrically controlled switches;
- a control panel mountable over an open front of the in-wall electrical box and having a user-interface to enable operation of said control panel by a user;
- a connection connected or connectable between the control panel and the switch module to enable transmission of signals from the control panel to the switch module, including control signals operable to control the plurality of electrically controlled switches of the switch module; and
- a communications transceiver operable to transmit and receive communications to and from each of the other electrical switch devices;

wherein:

the control panel of each electrical switch device comprises a touch-screen display, and is configured to display virtual on-screen switches on said touch-screen display, including at least one virtual switch whose output is assigned to a respective one of the electrically controlled switches of the other electrical switch devices, whereby the at least one virtual switch at one of said electrical switch devices is operable to control at least one load at another of said electrical switch devices; and

the control panel of each electrical switch device is configured to enable change of the touch screen display between a switching mode showing the virtual on-screen switches, and one or more pre-set modes with selectable pre-sets for the load circuits of one or more of the electrical switch devices.

2. The system of claim 1 wherein the control panel of each electrical switch device is configured to enable user-selected naming of the electrically controlled switches of the switch module of that electrical switch device, and the control panel of each electrical switch device is configured to automatically label the at least one virtual switch on the touch-screen display with a user-selected name of the respective one of the electrically controlled switches to which the output of the virtual switch is assigned.

3. The system of claim 1 wherein the control panel of each electrical switch device is configured to enable change of the touch screen display between a local pre-set mode with selectable pre-sets for one or more loads connected to a singular one of the electrical switching devices, and one or more wide pre-set modes with selectable pre-sets for a plurality of loads connected to a group of the electrical switching devices.

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